International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN (P): 2249-6890; ISSN (E): 2249-8001
Vol. 8, Issue 3, Jun 2018, 735-742
© TJPRC Pvt. Ltd.

TRANS STELLAR
•Journal Publications •Research Consultancy

TO DESIGN AND STUDY THE PARAMETERS OF GEARS USING POWDER METALLURGICAL PROCESS

SANJEEV KUMAR. A. P, ARJYO CHOWDHURY, DIGVIJAY SINGH & SARTHAK SRIVASTAV

Department of Mechanical Engineering, SRM IST, Delhi, NCR Campus, Uttar Pradesh, India

ABSTRACT

The residual porosity is an unavoidable phenomenon of the components produced by powder metallurgy process which in turn largely affects the strength property of the same. Now a day it is possible to control the porosity of powder metallurgy components and retain them to the desired amount when required. The porosity of a powder metallurgy component greatly depends on the sintering temperature. In this study, the porosity variation of a powder metallurgy component with respect to its sintering temperature will be explored where the fractional porosity of the powder metallurgy component will be derived from the sintered density and also will be observed the hardness variation of the same with respect to sintering temperature. An experimental approach will be made to study the porosity, hardness and density variation of a powder metallurgy component with respect to its sintering temperature where the fractional porosity, hardness and density of the component will be derived. We have mainly focused on the effects of sintering temperature on physical properties of powder metallurgical components. We have done the process like Ball Milling Mixing method, single acting cold compaction method and use of vacuum furnace of pre-sintering and sintering of the compacts. The measurements are done using the rock well hardness tests and also some usage of Universal Testing Machine is also done.

KEYWORDS: D3 Compound, Gear and Pinion, Hardness Testing Machine, Sintering Temperature & Vacuum Furnace

Received: Apr 17, 2018**; Accepted:** May 08, 2018; **Published:** May 30, 2018; **Paper Id.:** IJMPERDJUN201878

Original Article

INTRODUCTION

Powder Metallurgy is defined as the art and science of producing metal powders and making semi-finished and finished objects from the individual, mixed or alloyed powders with or without the addition of nonmetallic constituents. Production of Powder Metallurgy parts involves mixing of elemental or alloy powders with additives and lubricants, compacting the mixture in a suitable die and heating the resulting green compacts in a controlled atmosphere furnace so as to bond the particles metallurgical. The resulting parts are solid bodies of metal with sufficient strength and density for use in diverse field of applications.

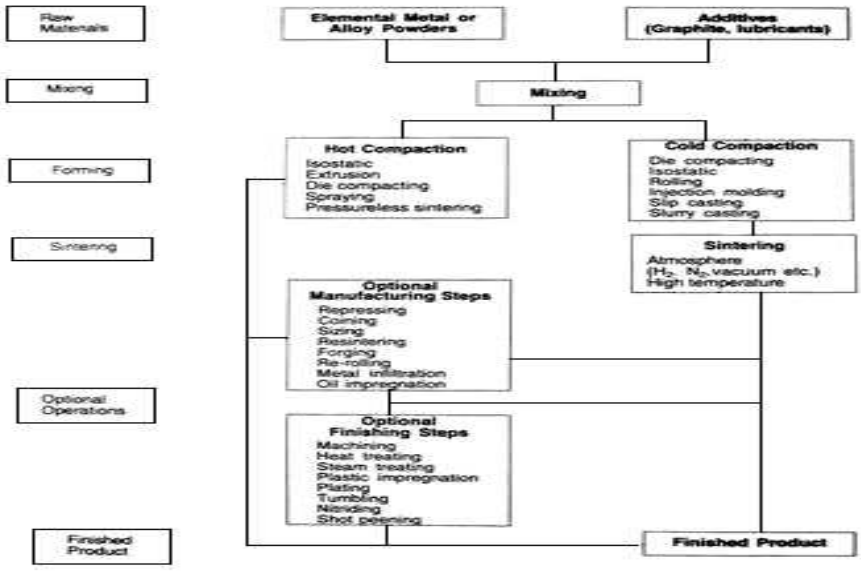


Figure 1: Process Flow Chart of Powder Metallurgy Components

Process Advantages of Powder Metallurgy Process

Powder Metallurgy offers the following important process advantages:

- Eliminate or minimizes machining (little or no scrap).
- Efficient materials utilization (above 95% material utilization).
- Enable close dimensional tolerances.
- To Produce good surface finish.
- Provides option for heat treatment for increasing strength or enhance wear resistance and plating for improved corrosion resistance.
- Facilitates manufacture of complex shape which would be impractical with other metalworking processes.
- Suitable for moderate to high volume components production requirements.
- It is a cost-effective process.
- Components of hard materials which are difficult to machine can be readily manufactured, e.g. tungsten wires for incandescent lamps.
- It is possible to produce components in pure form. Purity of the starting materials can be preserved throughout the process.
- Energy efficient process.
- Environment friendly process.

Metallurgical Advantages of Powder Metallurgy Process

Powder metallurgy enables the production of:

- Powders with uniform composition with the desired characteristic, resulting from the absence of segregation during solidification. These characteristics will be reflected in the finished parts.
- Elemental and pre-alloyed powder.
- A unique composition including non-equilibrium composition and microstructures (crystalline, nanocrystalline and amorphous)
- The wide variety of materials, metals and alloys of miscible and immiscible systems, refractory metals like tungsten and molybdenum, ceramics, polymers and composites.
- Parts with controlled porosity.
- Materials with improved electrical and magnetic property.

Commercial Advantages / Special Characteristic of Powder Metallurgy Parts

Important commercial advantages of Powder Metallurgy include:

- Ferrous and nonferrous powder metallurgy parts can be oil-impregnated to function as self-lubricating bearings. Similarly, parts can be resin- impregnated to seal-interconnected porosity to improve density or they can be infiltrated with a lower melting point metal for greater strength and shock resistance, and for making electrical contacts.
- Parts can be heat-treated and plated if required. Powder metallurgy parts are also amenable to processing by conventional metal-forming processes like rolling and forging.
- Cost-effective production of simple and complex parts, very close to final dimensions at production rates that can range from a few hundred to several thousand parts per hour.
- Offers long-term performance reliability in critical applications.

Advantages of Powder Metallurgy Processing over Conventional Metal Processing

The main advantages of Powder metallurgy processing over conventional metal processing methods such as casting,

Forging, rolling may be classified as follows:

- Improved microstructure resulting in porosity improvement as well as materials with novel microstructures.
- Materials such as Cemented Carbides, Refractory Metals, and Oxide Dispersion strengthened materials, friction materials, porous materials can be produced by powder metallurgy route alone.
- Improved product economics.
- Energy conversion and high level of material utilization.

A UNIQUE MANUFACTURING PROCESS OF POWDER METALLURGY PROCESS

In addition, there are several reasons for using the powder metallurgy route to produce engineering components. These include:

- Production of porous materials: These materials contain deliberately introduced porosity in significant amount, but controlled very carefully. Examples include, oil filters and self-lubricating bearings, which are very difficult to produce by any other method.
- Refractory metals: Powder metallurgy is a well-established method for producing components from refractory metals such as tungsten and molybdenum since it is difficult to melt these metals, because of their high melting points (>2000ºC). Powders of these metals are compacted, sintered and mechanically worked to form suitable products.
- Special alloys: Superalloys and high-speed steels can be readily synthesized by the powder metallurgy route, giving a fine and homogeneous microstructure with enhanced properties, with minimum wastage.
- Composite materials and newer materials combinations: Composite materials made by powder metallurgy route include a combination of insoluble metals (Cu-W, Cu-Ag, Cu-Fe and Ag-Cd), the metal-ceramic combination such as Al-Al2O3as well as hard metals like cemented carbides of tungsten, titanium and tantalum. Such combinations are not easy to produce with conventional processing.
- Powder metallurgy route can also be used to synthesize amorphous and nano crystalline materials.

 Structural components: Powder metallurgy route enables near-net shaping of several

 Structural components from iron, copper, aluminum, titanium and their alloys

GEAR TERMINOLOGY

The gear and the pinion manufactured are spur gears which perfectly mesh with each other. Now let us design the various parameters of the gear and the pinion. The gear terminology is shown in the below diagram.

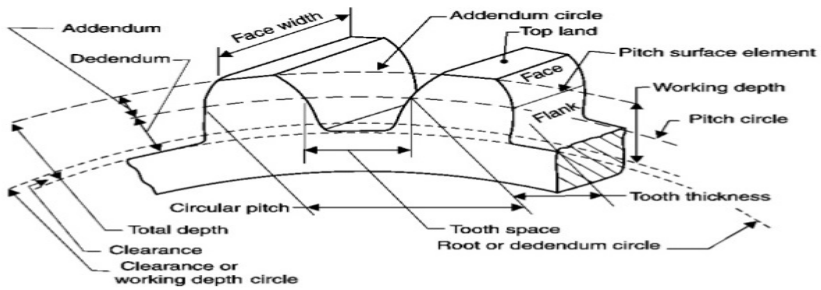


Figure 2: Gear Terminology

DESIGN OF THE GEAR

We have made two gears with pitch circle diameter of 100 mm and addendum circle diameter of 112 mm. The module of both the gears is taken as 6. The system of the teeth in both the gears is involate full depth having a pressure angle of 20˚. The number of teeth in both the gears is 18.



Figure 3: Design of Gear

- Pitch Circle Diameter = 100mm
- Number of teeth (T) = 18
- Module (m) = 6mm
- Pitch of the gear = π x m = π x 6= 18.84 mm

 Addendum circle diameter = pitch circle diameter + 2 x module

 = d + 2x6 = 112 mm

 Hence the Addendum circle diameter (d) = 112 mm

 Circular pitch (CP) = (π x d)/T = (π x 100) / 18

 = 17.45 mm
- Deddendum Circle Diameter = d- (2 x 1.157 x m)

 = 100 – (2 x 1.157 x 6) = 86.11 mm
- Clearance = 0.157 x m = 0.157 x 6 = 0.942 mm
- Tooth thickness = CP/2 = 17.45/2 = 8.72 mm
- Diametric pitch (DP) = T/d= 18/100 = 0.18 mm
- Addendum = module (m) = 6 mm
- Deddendum = 1.157 x m = 1.157 x 6 = 6.942 mm
- Full depth of teeth = addendum + deddendum

 = 6 + 6.942 mm = 12.942 mm
- Working Depth = 2 x m = 2 x 6 = 12 mm
- Face width = 20 mm
- System of teeth = involute, full depth
- Pressure angle = 20˚

DESIGN OF THE PINION

We have designed a pinion having an addendum circle diameter of 72 mm and a pitch circle diameter of 60 mm. the module of the pinion is 6 mm. The pinion has a teeth system of full depth involute and a pressure angle of 20˚. The number of teeth is 10.



Figure 4: Design of Pinion

- Pitch Circle diameter = 60 mm
- Module = 6mm
- Addendum circle diameter = 60 + 2 x 6 = 72mm

 Deddendum circle diameter = 60 – 2 x 1.157 x 6= 46.11 mm
- Diametric pitch =T/d = 10/60 = 0.166 mm
- Pressure angle = 20˚
- Number of teeth (T) = 10
- Clearance = 0.157 x m = 0.157 x 6 = 0.942 mm
- Circular pitch = (π x d)/T = 18.84 mm
- Tooth thickness = 18.84/2 = 9.42 mm
- Diametric Pitch = 10/60 = 0.166 mm
- Addendum = module = 6 mm
- Deddendum = 1.157 x m = 6.942 mm
- Face depth of teeth = 12.942 mm
- Face Width = 20 mm
- Working Depth = 2 x m = 12 mm

RESULTS OF THE EXPERIMENT

The different parameters of the Gears and pinion are given below:

Table 1

Gearand Pinion No.	Density	Hardness	Porosity
G_1	$7.34x10^{-6}$ kg/mm^3	125.4	0.0807
G_2	$7.67x10^{-6}$ kg/mm^3	124.6	0.0804
P_2	$6.44x10^{-6}$ kg/mm^3	125	0.0705
P_2	$6.58x10^{-6}$ kg/mm^3	128.7	0.0712

CONCLUSIONS

- The total fractional porosity (γ) of pins prepared through a powder metallurgy process is decreasing with the increase in sintering temperature.
- Mean Density (ρp) of pins prepared through a powder metallurgy process is increasing with the increase in Sintering Temperature. It is mainly due to the decrease in total fractional porosity of the sample with the increase in sintering temperature.
- Mean Hardness BHN of Gears and Pinions prepared through a powder metallurgy process is increasing with the increase in Sintering Temperature. It is also due to the decrease in total fractional porosity of the sample with the increase in sintering temperature.
- It has also been observed that, there having a significant difference in Hardness BHN, measured on Surface: 1 & Surface: 2 of Gears and Pinions. Mean Hardness of Surface: 2 having a higher value than that of Surface: 1, which is mainly due to the reasons of preparing the Inserts by Single Ended Compaction and non-uniform porosity distribution throughout the volume of powder metallurgy component.

REFERENCES

1. *Angelo P.C. "Powder Metallurgy: Science, Technology and Applications", © 2008 by Prentice-Hall of India Privet Limited, New Delhi: 110001.*
2. *Sinha A.K. "Powder Metallurgy", © 2003 DhanpatRai Publications (P) Ltd., 67/4, Madras House, Dariyaganj, New Delhi: 110002.*
3. *Smith William F., "Foundation of Materials Science and Engineering" (Second Edition), © 1993 by McGraw-Hill, Inc.*
4. *Sudhakar B., "An Analytic Study of Porosity Evolution in Powder Metallurgy Forming Process", © 1993 IEEE.*
5. *JhaBikash Kumar, the M-Tech. Thesis on "Tribological Testing of Fe-W-Co-Cr-Ti-C Alloy Used As Cutting Tool Prepared Through Powder Metallurgy", NITTTR, Kolkata, in the year 2011.*